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A PLEISTOCENE FLORA FROM THE McKITTRICK ASPHALT DEPOSITS OF CALIFORNIA

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THE KNOWN Pleistocene floras of California are largely coastal in their position and contain a group of species as fossils that are essentially maritime in their occurrence today. Of these by far the richest as to species content are the Tomales flora (1) in Marin County and the Carpinteria flora (2) in Santa Barbara County. Both of these contain a Monterey type forest dominated by pines and containing cypresses and live oaks as well as an understory of shrubs that is highly diversified as to genera and species. The asphalt deposit at Rancho La Brea (3) in Los Angeles County, although near the coast, contains a flora that is essentially interior in its nature and is best represented today by the open woodland vegetation on the slopes of the Tehachapi Range. The occurrence in this deposit of a few specimens of maritime species, however, suggests that at least a part of the drainage basin contributing to this deposit was populated by a maritime flora. It seems most likely that a mountain range such as the Santa Monica Mountains lay between it and the sea and that the coastal slope of these mountains was covered by a maritime flora which extended over the top and a short distance down the interior side much as does the coastal pine forest today on Cedrus Island off the Lower California coast. Only a very few strictly interior floras of Pleistocene age in California are as yet known and these contain very few species of plants. We therefore know very little as to the nature of the interior California floras during Pleistocene time and hence welcome any information, however meager, that will help us to piece together a picture of the vegetation of the interior for this period of the earth's history.

In the asphalt deposits at McKittrick in western Kern County, California, such a fossil flora occurs. The McKittrick deposit is located at the southwestern edge of a small oil town of the same name in the southwestern San Joaquin Valley just east of the base of the Temblor Range. The elevation of McKittrick is 300 feet while the Temblor Range rises to about 4000 feet. The geology of the area has been reported by Arnold and Johnson (4) and will not be further treated here. The rich fossil faunas have been described and discussed by Merriam and Stock (5, 6) for the mammals and by Miller (7, 8) for the birds. Summaries of these latter papers are presented by Hay (9). Arguments as to the precise position of these beds in the Pleistocene have been presented and discussed at length by these authors. The plant species that are at all critical in this respect all go back to the Pliocene both north and south of this area and are still living both north and south of this area and hence can throw very little light, if any, upon this problem. The Pleistocene status of the flora is inferred from the associated fauna which is largely made up of now extinct species.

The flora, however, does have a contribution to make as to the general ecological setting and can serve to a large extent in forming the basis for an interpretation of the habitat and the local climate for the portion of the Pleistocene represented. It will fill out the ecological picture presented in part by the mammalogist and in part by the ornithologist.

Merriam and Stock (5, 6) report the occurrence of horses, bison, camels, antelope, bear, lion, tiger, wolf, ground sloth and mastodon, all of which are now extinct. These are largely plains or savanna types of animals. Miller reports a list of thirty-five birds of which water birds predominate by two to one. Only 10 per cent of the birds are now extinct.

To date six identifiable plant species have been found. These consist of two gymnosperms and four angiosperms. Although the flora is meager these plants are sufficiently critical as to their climatic tolerance to serve as indicators of the nature of the flora and of the climate that prevailed in the McKittrick region during Pleistocene time. It may be that some future excavations will yield a flora comparable in quantity as well as in quality to other asphalt deposits in California but for the present we must be content with what there is.

The plants are represented in the deposit by fragments of poorly preserved fruiting structures and seeds as well as scraps of partially disintegrated twigs. These are imbedded in sand that has been impregnated with asphalt. The advanced state of deterioration of so much of the plant material suggests that the impregnation of the asphalt occurred after the plants were deposited and after preliminary decomposition had set in. There is not the evidence of a pool of asphalt such as is suggested by the conditions at Rancho La Brea. As compared with equal volume of matrix from other asphalt deposits the plant material in the McKittrick is rare. Most of the species are represented by single specimens. In only one case, the *Atriplex,* is there sufficient material

to give any notion as to the range of morphological variation of the structure. Fortunately, however, most of the material is of such a nature as to be readily identifiable and the following species may be recorded:

Pinus monophylla Torr.
Juniperus californica Carr.
Atriplex lentiformis (Torr.) Wats.
Arctostaphylos glauca Lindl.
Arctostaphylos pungens H.B.K.
Echinocystis fabacea Naud.

All of the above species found in the McKittrick flora are still living in the California flora today. The occurrence of all of them in a single Pleistocene flora presents a harmonious ecological picture that is not unlike an assemblage in the modern flora of the eastern end of the San Rafael Mountains in northeastern Santa Barbara County, on the slopes of Santa Barbara Canyon a little above its entrance upon the Cuyama Valley. (United States Geological Survey, Santa Ynez Quadrangle, R 25 W, T 9 N, in the Santa Barbara National Forest.)

The San Rafael Mountains in this vicinity range from altitudes slightly in excess of 600 feet to altitudes near 7000 feet. The great differences in altitude and the roughness of the terrain are reflected in great local diversity of the flora. A profile section of the San Rafael Range in this region in the direction of the storm paths will help to explain why a region so close to the coast supports such an arid type of vegetation. There are three prominent ridges separated by the canyons of Manzana Creek and the Sisquoc River. The westernmost of these ridges reaches an altitude of 4000 feet at Zaca Peak directly above the 1500-foot Santa Ynez Valley. The canyon of Manzana Creek drops precipitously to 1700 feet. The ridge between this canyon and the canyon of the Sisquoc River rises to a height of 3500 feet and is clothed with a very arid type of vegetation. The canyon of the Sisquoc drops to 2300 feet and the third and highest ridge culminates in Pine Mountain at 6800 feet with a northward spur of about 5800 feet forming the west wall of Santa Barbara Canyon. These ridges serve to force the moisture-laden winds from the ocean upward and causes them to deposit their load on the westernmost ridge and the upper part of the easternmost high ridge. This condition is reflected in the vegetation of these ridges. The western slope of the first ridge is clothed with a savanna type of cover except where the topography causes rapid runoff. Here the vegetation is chaparral. The top of this ridge is clothed with a forest of big cone spruce (*Pseudotsuga macrocarpa*), Coulter pine (*Pinus Coulteri*) and western yellow pine (*Pinus ponderosa*), which runs down the canyons and gullies on the east side. The second ridge, as was pointed out above, is clothed with a very sparse, arid type of chaparral. The third ridge is arid below the 4000-foot level but above is clothed with a very rich coniferous forest of big cone spruce, Coulter pine, western yellow pine and sugar pine (*Pinus Lambertiana*). It is the lower slopes of the east side of this ridge

that contain the flora represented in the McKittrick asphalt deposit. Here is an arid type of flora of scattered stands of pinyon pine (*Pinus monophylla*) and California juniper (*Juniperus californica*) and patches of manzanitas (*Arctostaphylos glauca*, *A. pungens* and *A. Parryana*). The other species represented in the fossil flora are abundant on the lower slopes and in the Pleistocene were probably much closer to the site of deposition than were the larger shrubs and trees.

Precisely where the particular plants that found their way to preservation in the McKittrick asphalt grew during Pleistocene time, is difficult to determine. It seems probable, however, that they were a part of the flora that occupied the Pleistocene Temblor Range and were borne down by the streams to the ponds and lakes that ultimately became silted up and infiltrated with asphalt. The pine, the juniper and the manzanitas, as well as the *Echinocystis*, probably occupied the higher slopes, while the *Atriplex* occupied alkaline flats near the ponds and marshes. This occurrence would explain the abundance of *Atriplex* and the relative scarcity of the other species in the deposit, since these latter would have to be transported by a none too rich stream flow.

Climatically the flora suggests an area of low rainfall but perhaps more than is received by the McKittrick region at the present time. This might lead some to argue that the flora indicates at least glacial time; however, in view of the close proximity of a similar modern assemblage of species it is more logical to assume that some minor changes in topography to the west would have accomplished the same result during the Pleistocene at McKittrick. If the Temblor Range were higher by 1000 feet, it might support such a flora around its summit. Evidence as to glacial or interglacial time is negative so far as the McKittrick flora is concerned.

Ecologically the flora is entirely consistent with the assemblage of mammals and of the birds. It was sufficiently open to permit grazing and browsing and, although the presence of *Atriplex* does not necessarily mean ponds and lakes, it frequently occurs near such sites today.

Since all of the plants represented in the McKittrick flora are modern species the nomenclature here used is that of the modern plants. In one of the plants the nomenclature of the modern group is not as yet stabilized, owing to incomplete knowledge and hence uncertain taxonomic concepts. In this instance it is felt that it is not within the province of this paper to solve these problems, nor could they be solved on the basis of the material here presented. The nomenclature for this species therefore follows current usage. The problem will be raised in connection with the species in question.

The specimens here cited are all deposited in the Palaeobotanical Collection of the University of California at Berkeley.

Pinus monophylla Torr.

(Plate 23, fig. 3)

Pinus monophylla Torr. in Fremont, Second Report, 319, 1845.

Pinus monophylla is represented by a cone, of relatively large size for this species, that is poorly preserved. The structure is practically reduced to vascular tissue but enough of the surface features of a few of the scales is preserved to show the essential nature of the apophysis and of the umbo as well as to clearly indicate the size and shape of the seed cavity. The cone is about 8 cm. long and about 7 cm. wide. The scales are terminated by a somewhat recurved, quadrate apophysis bearing a dorsal umbo. The seed cavity is ovoid, about 12 mm. long and 8 mm. wide, indicating a relatively large seed.

Pinus monophylla ranges primarily to the east of the Sierra Nevada. A few stations have been recorded for its occurrence on the west slopes of the Sierra. It occurs also in the Tehachapi and the Mount Pinos region, and extends northward in the coast ranges to the Cuyama Valley in the San Rafael Mountains, and on the watershed of the headwaters of the Santa Ynez River.

University of California Palaeobotanical Collections, Plesiotype no. 2810.

Juniperus californica Carr.

(Plate 23, fig. 1)

Juniperus californica Carr. Rev. Hort. 352, 1854.
Juniperus californica Carr. var. *breaensis* Frost, Univ. Calif. Publ. Bot. 14:77, 1927.

Juniperus californica Carr. is represented in the fossil flora by a seed 8 mm. long by 5 mm. wide that in no way differs from seed of the modern species as it occurs in the Tehachapi Mountains today. The seed coat is of medium thickness, and agrees with other Pleistocene material collected from the asphalt deposits at Rancho La Brea and described by Frost as distinct from the modern plants.

The modern *J. californica* Carr. is an aggregate species that includes with varietal rank the desert and Great Basin form *J. utahensis* (Engelm.) Lemmon. These two forms intergrade in the region of the Tehachapi Mountains so as to make their separation as distinct species impossible. They have been separated on the basis of the glandular nature of the foliage of typical *J. californica*. Another important difference is the relative thickness of the seed coat in the extremes of the two forms. Typical *J. californica* has a thin seed coat while typical *J. californica* var. *utahensis* has a very thick seed coat. Both the characters of the seed coat and of the glandulosity intergrade in material collected by the writer from the Tehachapi Mountains and from the Sierra Liebre in California (see *Mason 3737*, Herbarium of the University of California). The fossil material from the McKittrick asphalt is of the intermediate type represented by this material. Because of its intermediate character it is impossible to designate whether it belongs to the species or to the variety.

In the fossil record *J. californica* has been reported from the asphalt depos-

its at Carpinteria and at Rancho La Brea. In the latter flora, however, the material was described as new under the name *J. californica* var. *breaensis* Frost. *J. californica* ranges from Lower California through the western Mojave Desert to the Tehachapi Mountains and northward in discontinuous patches in the inner coast ranges to Shasta County and sparingly on serpentine soil in the Sierra Nevada foothills to Butte County. It is of interest to the present paper to record it in abundance in the inner south coast ranges that border the Cuyama Valley.

University of California Palaeobotanical Collections. Plesiotype no. 2811.

Atriplex lentiformis (Torr.) Wats.

(Plate 24, figs. 1, 2, 3)

Atriplex lentiformis (Torr.) Wats. Proc. Am. Acad. 9:118, 1874.

The species is represented by a large number of fruiting bracts often enclosing fragments of the seed coats. They are flattened and wedge-shaped. Some of them possess a stipe while others appear to have been sessile on the branch. They average 4 mm. in length and 5 mm. in width. The bracts are united below over the seed and are apparently free above. The upper margins are somewhat broken and it is difficult to reconstruct the character of these organs. There is evidence to indicate a fringed, denticulate margin. The surface shows a coarsely reticulate venation and is entirely devoid of any facial processes.

It seems evident from a careful comparison of the specimens that but a single species of the genus is represented. The great range of variation exhibited by many of the modern species shows forms that are not unlike the fossils. However, each species has a characteristic kind of fruiting structure and its variation centers around this type. Of the modern species now living in California, *A. lentiformis* seems closest both on morphological and ecological grounds. The area wherein this flora is best represented today is rich in species of *Atriplex* and any or all of them might well have been living in the McKittrick locality during the Pleistocene.

The genus *Atriplex* has been recorded from the Pleistocene Tomales flora of central California where fossil material of the coastal species of *A. hastata* has been collected.

University of California Palaeobotanical Collections, Plesiotype no. 2812.

Arctostaphylos glauca Lindl.

(Plate 24, figs. 4, 5, 6)

Arctostaphylos glauca Lindl. Bot. Reg. sub t. 1791, 1835.

This large-fruited species of manzanita is represented in the fossil flora by fragments of fruits one of which is 12 mm. in diameter, with its carpels closely coalesced so as to present a very smooth surface. The material is identical with similar structures on the modern *A. glauca* and is clearly referable to that species.

The modern plant is a characteristic species of the Upper Sonoran life zone in the blue-oak-digger pine belt, and ranges from central California southward to southern California. It is frequent in the Tehachapi Mountains and the inner south coast ranges in association with juniper. Its occurrence in the fossil flora suggests conditions similar to those of these mountains at an altitude of about 3000 feet.

Arctostaphylos glauca is known in the Pleistocene from both the Carpinteria and the Rancho La Brea asphalt deposits. It is an indicator of arid interior conditions (Chaney and Mason, 2).

University of California Palaeobotanical Collections, Plesiotype no. 2813.

Arctostaphylos pungens H.B.K.

Arctostaphylos pungens H.B.K. Nov. Gen. et Sp. 3:278, 259, 1818.

This species is represented in the fossil flora by a fruit 4 mm. long and 6 mm. wide with coalesced carpels. The individual carpels show unequal development and present a strongly ribbed appearance to one side of the fruit. The specimen is not unlike many that are of frequent occurrence on modern plants of *Arctostaphylos pungens* of the inner south coast ranges.

Arctostaphylos pungens is a species of the arid hills bordering on the upper part of the Sonoran and the lower part of the Transition zones from central California southward. Its precise range cannot at present be stated because it is obvious that what has been going under the name of *A. pungens* in current floras of the region is not the same as the plant originally described under that name from the vicinity of Mexico City. Furthermore, there is considerable confusion about the taxonomy of the group locally and until this problem can be straightened out by a monographer of the genus as a whole the precise name must stand in abeyance. It is possible that *A. montana* Eastwood and *A. Hookeri* Don may be involved in relationship here to such an extent as to involve the nomenclature of the fossils. At any rate, the specimen under consideration is of a type like the modern plants of this group now growing in the inner south coast ranges of California and referred to in modern floras as *A. pungens*.

University of California Palaeobotanical Collections, Plesiotype no. 2814.

Echinocystis fabacea Naud.

(Plate 24, figs. 8, 9)

Echinocystis fabacea Naud. Ann. Sci. Nat. ser. IV, 12:154, 1859.

Fragments of the seed coat of this species preserved in this deposit differ in no way from the modern species that is so widespread in the inner and outer coast ranges of California. Identification was based upon the histological nature of the seed coat, where there are two very different layers of cells evident, an inner layer composed of narrow cylindrical cells and an outer layer about three times as thick composed of many irregularly rounded cells.

The inner face of the seed coat is lined with a very soft spongy tissue that readily sloughs off. *Echinocystis fabacea* ranges throughout the inner and outer coast ranges of central California, crossing the Tehachapi Mountains to the Mojave Desert, where it has been reported in the vicinity of Muroc. It is not common in the Sierra Nevada foothills, but is abundant in the inner south coast ranges.

University of California Palaeobotanical Collections, Plesiotype no. 2815.

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EXPLANATION OF PLATES

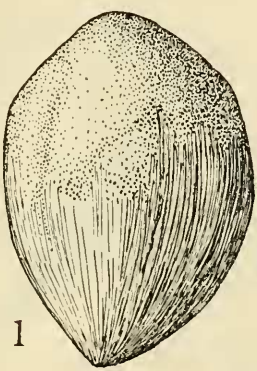
PLATE 23

Gymnosperms in the McKittrick Flora

Fig. 1. *Juniperus californica* Carr., drawing of the fossil, × 6. Univ. Calif. Palaeobot. Coll., Plesiotype no. 2811.

Fig. 2. Seed of a modern plant of *Juniperus californica* Carr., × 1.

Fig. 3. Cone of *Pinus monophylla* Torr. × 1. Univ. Calif. Palaeobot. Coll., Plesiotype no. 2810.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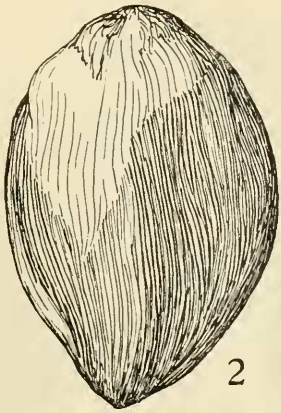
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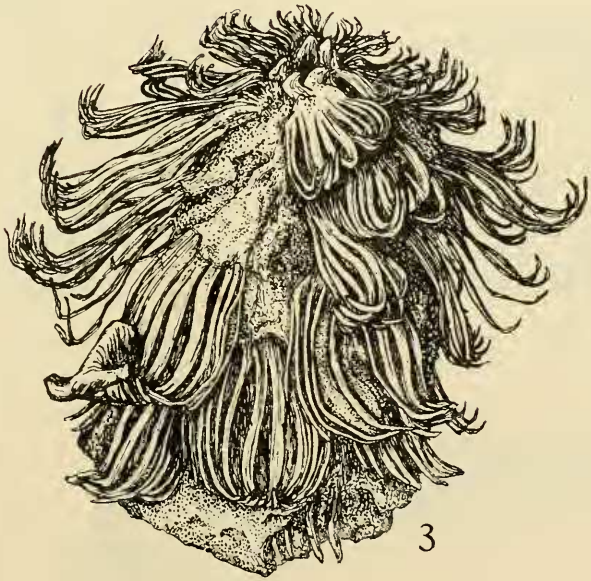
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PLATE 24

Angiosperms in the McKittrick Flora

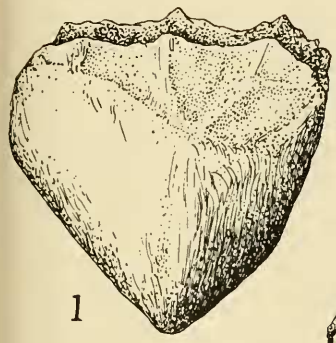
Figs. 1, 2, 3. *Atriplex lentiformis* (Torr.) Wats. Fruiting bracts, ×10. Univ. Calif. Palaeobot. Coll., Plesiotype no. 2812.

Figs. 4, 5, 6. *Arctostaphylos glauca* Lindl. Fragments of fruit. Figs. 4 and 5, ×4; fig. 6, ×5. Univ. Calif. Palaeobot. Coll., Plesiotype no. 2813.

Fig. 7. *Arctostaphylos pungens* H.B.K. Endocarp of fruit, ×8. Univ. Calif. Palaeobot. Coll., Plesiotype no. 2814.

Fig. 8. *Echinocystis fabacea* Naud. Cross section of the seed coat of a modern specimen showing the two layers of the seed coat, ×15.

Fig. 9. *Echinocystis fabacea* Naud. Cross section of the seed coat of the fossil, ×15. Univ. Calif. Palaeobot. Coll., Plesiotype no. 2815.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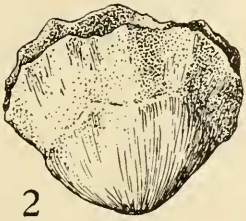
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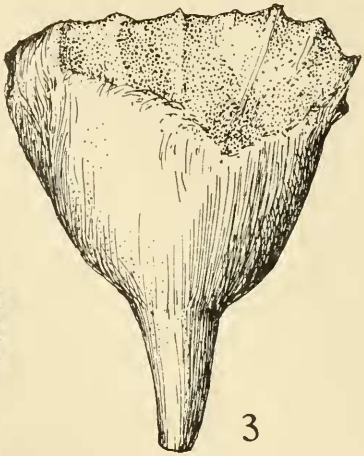
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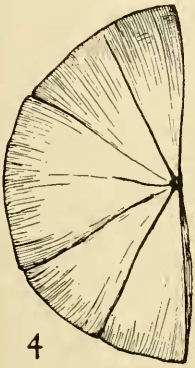
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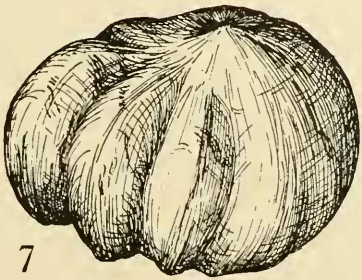
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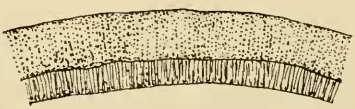
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